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Digitally Generated CPFSK IF Test Signals Including Phase Noise

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Abstract—We present a simple, all electrical method for the generation of test signals for testing of fiber-optic coherent CPFSK IF receiver systems, using a programmable bit error rate tester. The feature to be able to add phase noise to the IF signal makes it possible to evaluate receiver system behavior with relation to local oscillator phase noise.

I. INTRODUCTION

THE choice for CPFSK modulation for coherent optical communication systems is attractive because of the simple laser modulation concept.

The generation of CPFSK IF test signals, which are used during the development of CPFSK receiver IF systems (Fig. 1) is, on the other hand, difficult. In our case, we have a communication system for a bitrate of 311 Mbit/s, a modulation index $m = 1$, and an IF bandwidth of 700 MHz centered at 465 MHz. To generate a CPFSK IF test signal, we would require a voltage controlled oscillator at 465 MHz, which can be swept over 311 MHz at the 311 Mbit/s bitrate. Practically, this is impossible. Another method has been presented [1], but this method requires several phase and frequency locked synthesized generators. Moreover, it does not take into account the phase noise. This latter phenomenon being of major importance in optical coherent communication systems.

II. DIGITALLY GENERATED SIGNALS

To synthesize the IF signal of a 311 Mbit/s heterodyne CPFSK receiver (modulation index $m = 1$, IF centered at 465 MHz) we would need a generator that is switched between $f_l = 311$ MHz and $f_h = 622$ MHz at the 311 Mbit/s rate, while the phase of the output signal should be continuous at the frequency change overs. This can easily be realized digitally by the simple setup, shown in Fig. 2. The output of a clock generator, running at twice the bitrate, is applied to an input of an AND gate and to a frequency divider (flip flop). The output of the divider is connected to an input of a second AND gate and to the clock input of a pattern generator. The data output of this generator is connected to the second input of the first AND gate and inverted to the second input of the second AND gate. Both AND outputs are "ORed" together

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Fig. 1. CPFSK receiver.

Fig. 2. Schematic diagram of the digital generation of a CPFSK IF signal.

Fig. 3. Composition of the CPFSK IF signal from the clock signal, twice the clock signal and the DATA signal.

and lowpass filtered. Fig. 3 shows a diagram of the various signals which compose at the end the CPFSK signal.

III. USING A PROGRAMMABLE BIT ERROR RATE TESTER

The availability of a programmable BERT [2] makes it even more simple to generate the desired IF signal. Fig. 3 shows that f_l is generated by a 0011 sequence, while f_h is generated by a 0101 sequence on the basis of the $2f_c$ clock.

These sequences can easily be programmed in the pattern memory of the BERT (Fig. 4, upper part). The first step is to download the standard test pattern (PRBS) from the BERT to a personal computer via the IEEE-488 interface. Then substitute a 0011 sequence for every 0 in the downloaded pattern and a 0101 sequence for a 1 data bit. Manchester coded CPFSK signals can be generated as well. In this case a data 0 results in a 00110101 sequence and a data 1 gives 01010011. In this last case, the clock rate of the BERT is eight times the data baud

Fig. 6. Receiver performance degradation ($\text{BER} = 1 \times 10^{-9}$) as a function of IF laser linewidth, for a 311 Mbit/s CPFSK receiver (modulation index $m = 1$).

Using the setup, we measured the performance degradation of a heterodyne CPFSK receiver due to the total laser linewidth of the transmitting laser and the local oscillator laser (Fig. 6). The results given in this figure are in perfect agreement with the results presented in [6].

VI. CONCLUSION

Using a programmable bit error rate tester is an attractive and simple alternative for a setup using frequency and phase

locked synthesizers or lasers to generate CPFSK IF test signals. The feature that enables testing the IF-circuitry, without using optical sources and components is, especially, an advantage. This testing includes both the additive noise and the phase noise.

The method presented in this paper is rather simple, but is limited as well. There has to be a relationship between the send frequencies and the bit rate. Nevertheless, small modulation indexes can be produced, including $m = 0.5$. This latter is achieved by taking the lower frequency equal to the bit rate and the higher one 1.5 times the bit rate. In that case, some extra processing (bit sequence dependent phase reversals of the constituting signals) may be required to guarantee phase continuity. In a similar way schemes for $m = 0.66$ and $m = 0.75$ were developed.

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